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[54] **CONSTANT INPUT ENERGY ABSORBING APPARATUS**

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[52] **U.S. Cl.**.....**272/73**, 272/DIG. 6, 322/28, 323/22 T

[51] **Int. Cl.**.....**A63b 23/04**

[58] **Field of Search**.....73/379 R; 272/73, 57 R, DIG. 6, 322/28; 323/22 T

[56] **References Cited**

UNITED STATES PATENTS

3,284,694	11/1966	Roof et al.	322/28
3,491,285	1/1970	Nowakowski	323/22 T
3,544,881	12/1970	Raver et al.	322/28 X
3,057,201	10/1962	Jaeger	73/379
3,505,992	4/1970	Jaeger	272/73
3,395,698	8/1968	Morehouse	73/379
3,419,732	12/1968	Lane	272/73
2,784,591	3/1957	Shoor	272/73

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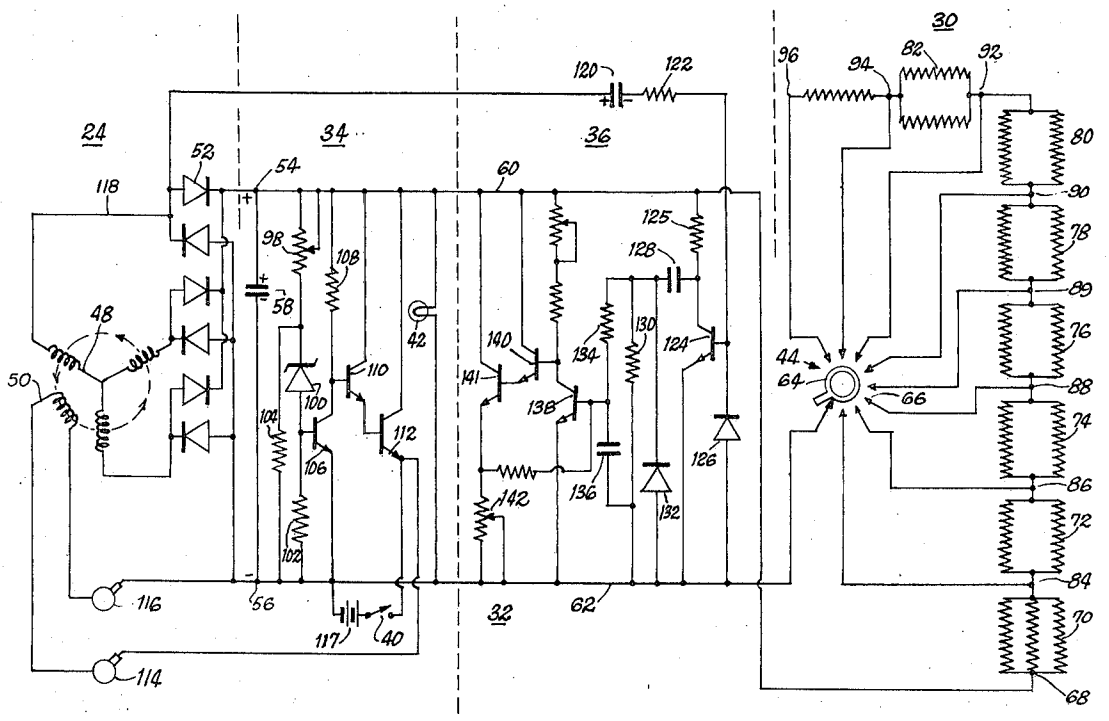
[57] **ABSTRACT**

An energy absorbing apparatus of the dynamometer type which in one embodiment is combined with a stationary exercising device. The apparatus includes a generator supplying a load to be connectively switched to the generator. A regulator maintains the output voltage of the generator at a constant value while an auxiliary load is provided and is controlled by a switch responsive to the variations in the rotation rate of the generator to maintain its horsepower input at a substantially constant value.

6 Claims, 7 Drawing Figures



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SHEET 1 OF 3

FIG. 1

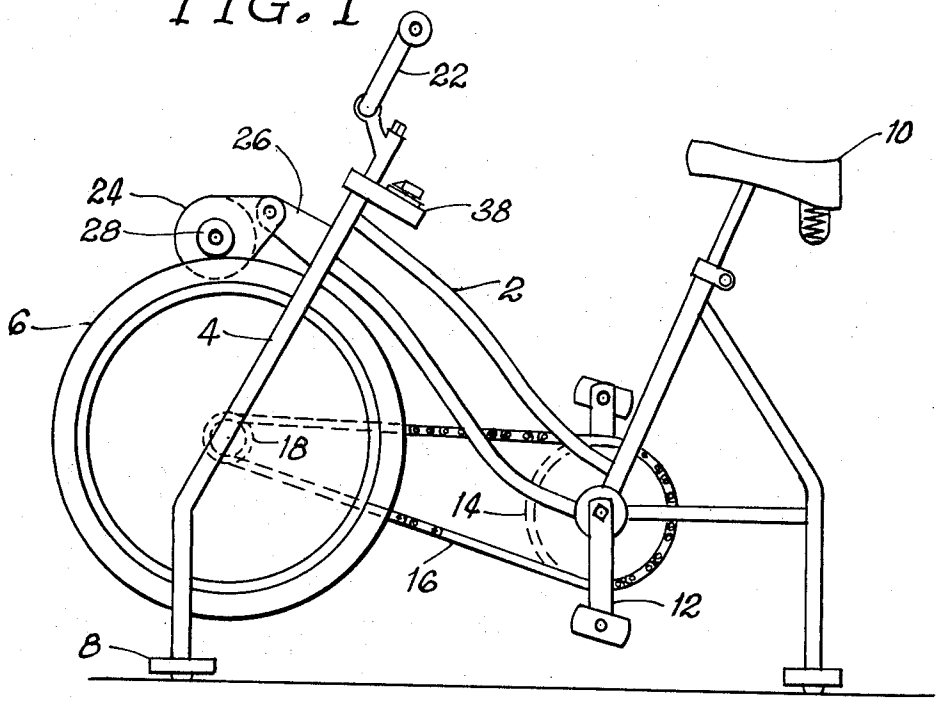


FIG. 2

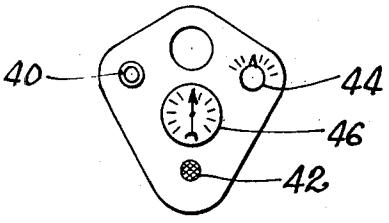
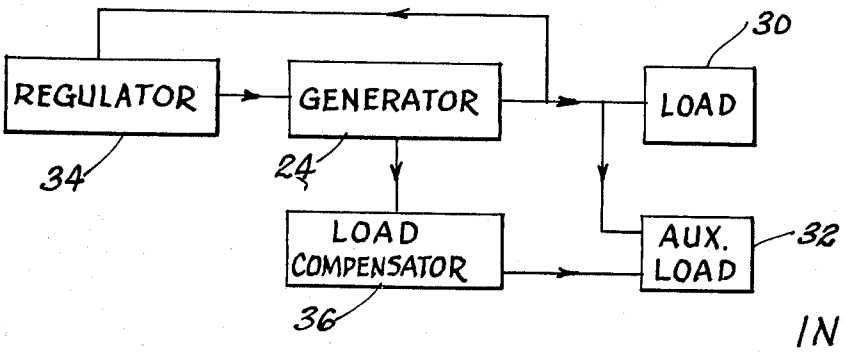


FIG. 3



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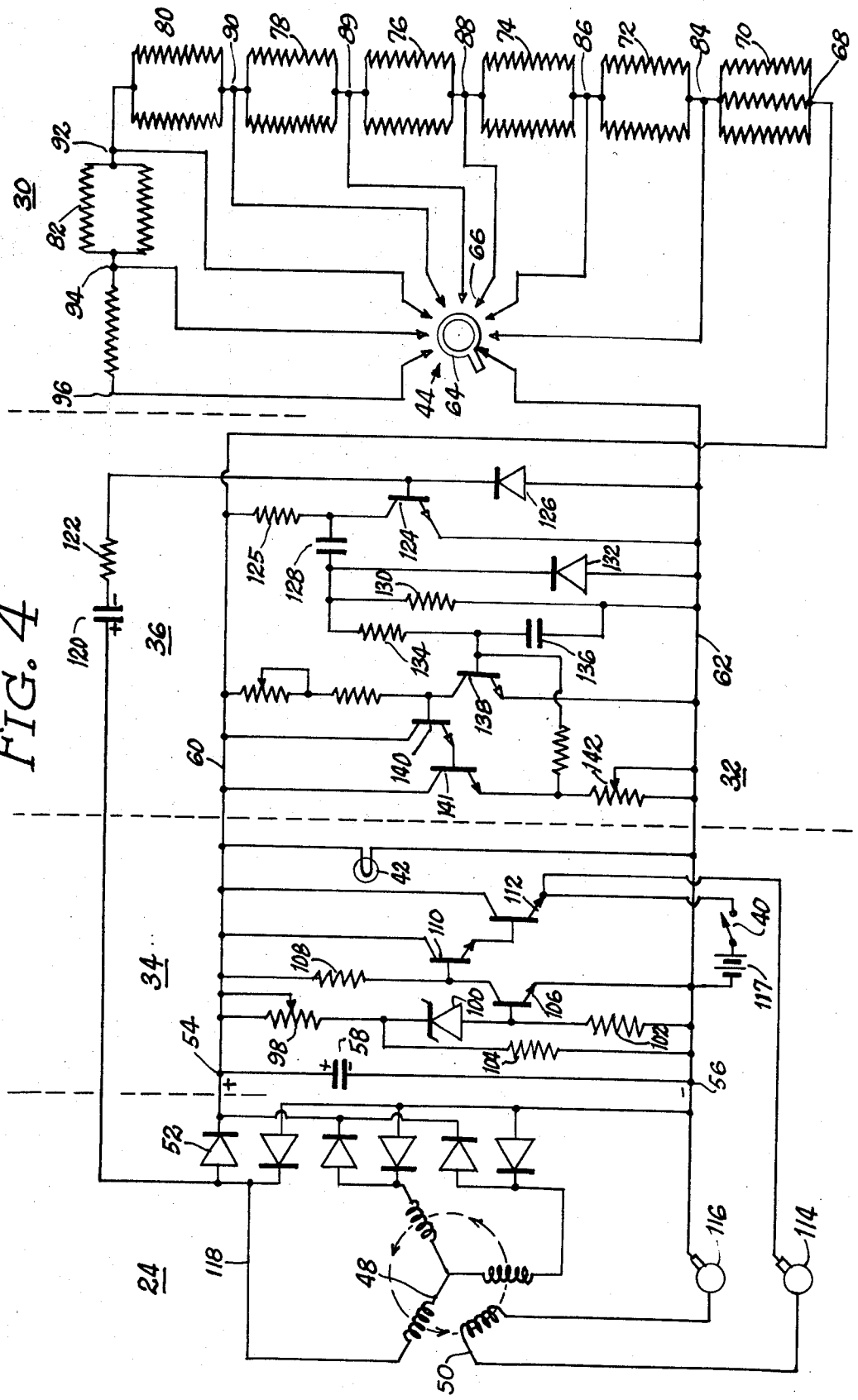
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FIG. 4

FIG. 5

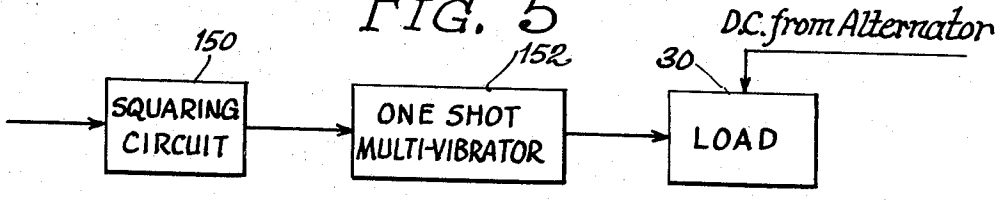


FIG. 6

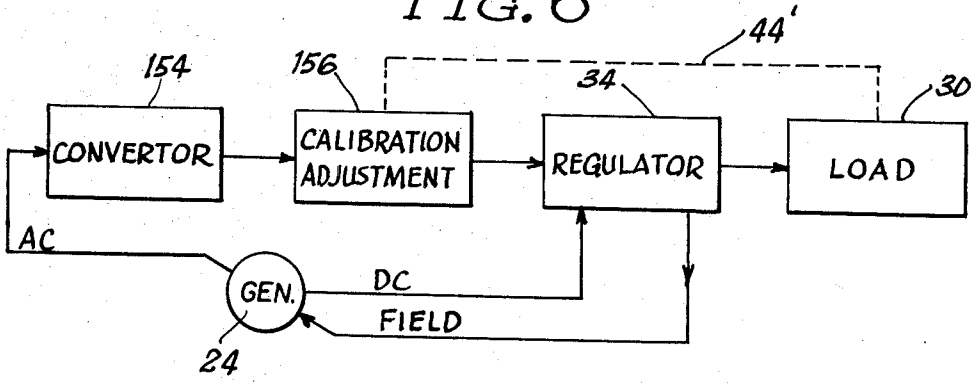
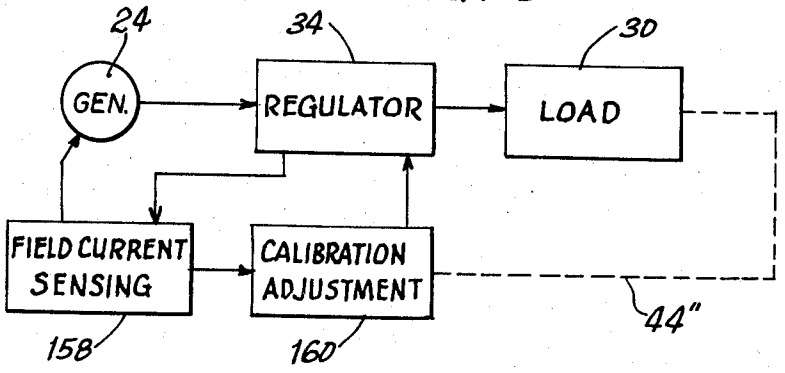


FIG. 7



CONSTANT INPUT ENERGY ABSORBING APPARATUS

BACKGROUND OF THE INVENTION

This invention relates to energy absorbing apparatus. More specifically, it relates to energy absorbers of the dynamometer type particularly useful in exercising devices.

Generally speaking, stationary exercising devices of the type where a user by moving his arms or legs turns a wheel connected to an energy absorbing device having used adjustable brakes to absorb the energy and to control the resistance to wheel movement. While such systems are satisfactory in many respects, they suffer from a number of disadvantages. Most of them require constant readjustment of the brake or other friction force by the user in efforts to maintain constant the energy expenditure on his part. Inasmuch as they are friction devices, they are subject to wear and therefore require periodic replacement. In a number of situations there is an additional problem when a regimen of exercise is carefully prescribed by a physician for patients who have suffered disabling or partially disabling disorders. In such situations as these, it is very important that the amount of energy to be expended by the patient be rigorously controlled. When an exercising device of the prior-art friction variety is used for this purpose, the lack of precision and variability render such devices unsuitable.

Therefore, it is an object of this invention to provide a novel exercising apparatus which is capable of accurate and consistent control of the amount of energy to be expended by a user.

It is another object of this invention to provide a novel exercising apparatus which is durable and utilizes a minimum of parts subject to wear and change of value.

While a particular application of the invention is in the combination with an exercising device, there are numerous other situations where it is desired to provide apparatus for absorbing the energy of rotating shafts. Thus, it is contemplated the invention in one of its aspects is a dynamometer having utility wherever it is desired to measure the performance of rotating machinery such as internal combustion engines, transmissions, electric motors, or the like.

SUMMARY OF THE INVENTION

Briefly, the above and other objects are achieved in one embodiment of the invention by the provision of a regulated electrical generator arranged to be driven by a rotatable element and supplying a load, the magnitude of which can be determined by an operator. Means are provided to maintain the horsepower input of the generator constant even though there may be variations in the speed of the rotatable element.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is set forth is the claims appended hereto and forming a part of this specification while various embodiments therein and their modes of operation are set forth in the detailed description taken in connection with the drawings in which:

FIG. 1 is an illustration of the invention in which a stationary exercising device is shown as the element producing energy to be absorbed;

FIG. 2 is an illustration of an operator's control panel which may be used in conjunction with the embodiment of FIG. 1;

FIG. 3 is a block diagram illustration of an embodiment of an aspect of the invention;

FIG. 4 is a schematic diagram of the embodiment of FIG. 2;

FIG. 5 is a block diagram illustration of another embodiment of a load compensation control forming a part of the invention;

FIG. 6 is a block diagram illustration of still another embodiment of a load compensation control forming a part of the invention; and

FIG. 7 is a block diagram illustration of another embodiment of the invention.

DETAILED DESCRIPTION

An energy absorbing device in one embodiment of the invention is illustrated generally in FIG. 1. In this figure, a stationary exercising device of the bicycle type comprises a frame 2. Mounted at the front end of the frame is fork 4 carrying a wheel 6 for rotation. The fork 4 extends to a suitable base 8 with the wheel supported in space so that it may be rotated in position. A seat 10 is provided for the user so that his feet may engage and cause rotation of a pair of pedals 12 attached to a drive sprocket 14 which thereby drives a chain 16 looped around driven sprocket 18 attached to the wheel 6. Conventional handlebars 22 are provided to be gripped by the operator. The device illustrated and described represents one form of this aspect of the invention. Other types of exercising devices that are contemplated where it is desired to provide leg exercise apparatus which permits the operator to select a standing, sitting, or prone position may be used. Alternatively, a device wherein the wheel 6 is to be rotated using the arms may be constructed.

In further accordance with the invention, the apparatus includes an electrical generator 24 secured to the frame 2 by a suitable bracket or support 26. The shaft of the generator 24 is provided with a drive wheel or pulley 28 engaging the wheel 6 so as to be driven thereby. While not shown in FIG. 1 but as illustrated in FIG. 3, the output of the generator is supplied to a main load 30 and auxillary load 32. As will be explained in greater detail hereinafter, a regulator 34 and a load compensation control 36 provide means to control the output of the generator so as to maintain its output constant. These latter elements may be packaged so as to minimize access to them by others than service technicians and to provide consumer "eye appeal" and mounted at convenient locations in the frame 2 or in a base structure for the exercising apparatus.

An instrument panel 38 may be attached to the handlebars 22 and as seen in FIG. 2 may include operator information and control elements. The instrument panel may include a start-up switch 40, a condition light 42, a load selection switch 44, and a speedometer or tachometer 46 having as an input a connection to the wheel 6. The light 42 and switchs 40 and 44 are connected in the circuit constituting an aspect of the invention as described in connection with FIG. 4.

As may be seen in FIG. 4, the generator comprise an alternating current generator having a wye connected stator 48 and a field winding constituted by a rotor 50. The output of the generator is connected to a rectifying

circuit 52 so as to provide a positive terminal 54 and a negative terminal 56. As may be seen, the generator is self-excited. In one actual embodiment of the invention, the generator used was a so-called "alternator" of the type used in motor vehicles. Such generators are readily available, economical, relatively light weight and reliable. Obviously, the practice of the invention does not require such a device but its advantages make it attractive. If desired, a capacitor 58 may be connected across the terminals 54 and 56 in order to smooth the output by filtering out any AC components.

In order to provide a load for the generator, the magnitude of which may be selected by a user, the output of the generator is supplied by the busses 60 and 62 to the switch 44 which is selected to be a multi-position switch having a rotary element 64 and a plurality of stationary terminals 66. The bus 62 is connected to rotary terminal 64 while the bus 60 is connected to one end 68 to a plurality of series connected resistors 70 through 82. Intermediate points 84 through 94 of the resistors are connected to respective ones of the stationary terminals 66 while an end point 96 is connected to its respective one of the terminals 66. Thus, by manipulation of the switch 44 a conductive lug on its rotary element 64 may be rotated into contact with any of the terminals 66 to connect one or more of the resistors to the buses 60 and 62 so as to alter the load on the generator 24. As seen in this figure rotation of the element 64 in a clockwise direction with the effect of increasing the load as less resistance is connected into the circuit, there are numerous variations in the load selection circuit which are known to those skilled in the art. For instance, the switch 44 and load circuit 30 maybe constituted by a continuously variable resistor device.

As stated previously, it generally is desirable to hold the output of the generator constant so that when in use the operator, if the embodiment is an exercise device, may be assured that he is supplying a constant voltage output to the selected load, or if the invention is applied as a dynamometer testing device, the output will remain constant in spite of load changes. To this end the regulator 34 is provided. FIG. 4 illustrates in detail a regulator which is particularly useful in the practice of the invention. However, it should be understood that any regulator, preferably solid state, including the standard elements of generator output sensing as an input, a reference value to be maintained and a difference error signal amplifier controlling field excitation may be used.

Thus, in FIG. 4, the generator output buses 60 and 62 have connected therebetween a voltage divider including a resistor 98 and a zener diode 100 and resistor 102. The zener diode 100 has its cathode terminal connected to the positive bus 60 through the resistor 98 so that if the positive voltage exceeds the zener value it will conduct in the reverse direction. A resistor 104 shunts the diode 100 so that only a fraction of the output voltage is used as an input to the regulator. An NPN transistor 106 has its base connected to the junction of the diode 100 and resistor 102 so that when the diode 100 conducts the transistor 106 conducts in turn, the collector of transistor 106 is connected to the positive bus 60 through a current limiting resistor 108 and to the base of another NPN transistor 110 connected as an emitter follower. Therefore, as transistor 106 conducts in response to the conduction of diode 100 the transistor 110 which has previously been conducting will tend to cease conduction as the collector voltage of transistor 106 decreases as a consequence of the conduction of that transistor. The emitter of transistor 110 is connected to the base of a third NPN transistor 112, the collector of which is connected to the positive bus 60 and the emitter of which is connected to a slip ring 114. The slip ring 114 is connected to one side of the generator field winding 50 while the other side of that field winding is connected through another slip ring 116 to the negative or ground bus 62. As may be seen, the connections and relative voltages are such so that emitter follower 110 is normally in a conductive state so that the transistor amplifier 112 is likewise in a conductive state. Assuming, therefore, the generator 24 is operating the field 50 is supplied with a voltage control connected by the conduction of transistor 112 to provide self-excitation. If the output voltage should increase above a value determined by the inverse characteristic of zener diode 100, the transistor 106 will conduct thus decreasing the conduction of transistors 110 and 112, and therefore the voltage of the field 50. As the field voltage drops the field current will decrease to cause the output voltage to decrease to the desired value.

Inasmuch as the generator 24 is self-excited, it is necessary to supply a voltage to the field 50 at start-up and until the output builds up to provide a sufficient voltage to overcome the forward voltage drop of the rectifiers 52 and to supply operating voltage for the regulator 34. A battery 117 with its negative terminal connected to the bus 62 is connected through the switch 40 which is normally connected to the slip ring 114. This switch which may be placed on the instrument panel 38 is closed by the operator upon start-up. As the generator is rotated by the rotation of the wheel 6 or other means, its output voltage will gradually build to a value where the conduction through the transistor 112 will be sufficient to maintain excitation. This may be sensed by the operator by looking at the light 42 which will light up so that he may release the switch 40.

It is desirable to provide that the horsepower input of the generator may remain constant in spite of variations arising as a consequence of changes in the RPM. In an exercising device, it is most likely that a user will not maintain a constant RPM and the input will vary due to varying internal machine losses which are functions of the RPM. Consequently, even when a particular load has been prescribed by a therapist and selected by the user the amount of energy expended by the user will not be the constant value desired unless the generator horsepower is maintained at a constant or substantially constant value regardless of variations in generator RPM. While the regulator will act to maintain the generator power output constant, there are energy losses which vary with RPM. These include losses in rotating or moving parts such as belts, bearings, sprockets, chains, etc. In addition, there are losses in the generator itself such as hysteresis and eddy current losses which likewise vary with RPM. Thus, if the output is to be held constant the input should be constant, but, where it is not, because of variations in RPM by a user, some means of compensating for such variations becomes desirable.

Generally speaking, the invention includes this capability by deriving a signal representative of generator frequency and therefore RPM and utilizing that signal to maintain the system energy input constant, independent of frequency variations.

In the embodiment of the invention illustrated in FIGS. 3 and 4, apparatus for this purpose utilizes a connection **118** to one end of a stator winding. In this manner, the A.C. output of one of the phases of the generator is derived and passed by D.C. component decoupling capacitor **120** and a current limiting resistor **122** to the base of a transistor **124**. The transistor **124** has its collector connected through a load resistor **125** to the bus **60** and is selected to be one which will allow transistor **124** to reach a constant value of collector saturation voltage and constant cut-off current by the values of applied current. Consequently, its output will be a square wave signal having the same frequency as the sine wave supplied to its base. Protection of transistor **124** against excessive negative voltage may be provided by a diode **126** poled as shown in the drawing connected between the base and bus **62**.

The output of the squaring circuit constituted by the transistor **124** is supplied to a differentiating circuit consisting of the capacitor **128** and resistor **130**. A diode **132** is connected between the capacitor **128** and bus **62** and poled to clip the negative spike output from the differentiator from the signal so as to provide a series of positive spikes having a frequency equal to the output frequency of the generator.

These spikes are supplied to an integrating circuit consisting of a resistor **134**, a capacitor **136**, and a transistor **138** so as to produce at the output of the transistor a negative going signal, the magnitude of which is proportional to the frequency of the generator. This signal is supplied to the base of a transistor **140** and thereby matched in impedance characteristics to drive the base of a transistor **141**. The inverted signal is supplied to the base of the transistor **141** connected between the positive bus **60** and an adjustable resistor **142** constituting the auxiliary load **32** con-nected to the negative bus **62**.

The operation of this circuit is such that as the frequency increases the signal supplied by the transistor **140** to the base of the transistor **141** will be effective to decrease its conduction. Thus, as the frequency increases a smaller percentage of the generator output will be dissipated in the resistor **142** and as the generator output frequency decreases a greater percentage of generator output will be supplied to that resistor. In this manner, variations in RPM and consequently generator frequency will be compensated for by diverting more or less generator output voltage to the compensating resistor **142**. Thus, the system will tend to maintain a horsepower which is constant or substantially constant in spite of variations of generator RPM.

In another embodiment of this invention as shown in FIG. **5**, the generator AC output is supplied to a squaring circuit **150**. The output of the squaring circuit is supplied to a one-shot multivibrator, the output of which is effective to selectively switch the auxiliary load **32** to the DC output of the generator.

The operation of this embodiment is as follows: The multivibrator **152** driven by the output of the squaring circuit **150** switches the auxiliary load **32** off for a preset, fixed time interval every cycle of the alternator. As the frequency increases, the fixed intervals of time during which the load is switched off become more numerous per unit of time. Thus, the average length of time the load **32** is dissipating, power is thus decreased as the frequency is increased. In this manner, there is provided a compensatory effect related to alternator rotation rate and in a direction such that increasing losses of the alternator are corrected.

FIG. **6** illustrates still another means for providing a frequency sensitive control. In this embodiment, a frequency responsive signal is supplied by means **154** to convert RPM to a voltage signal as an input to the regulator **34** so that voltage regulation is both frequency and amplitude responsive in such a way as to reduce the output voltage as frequency increases. In order to provide a calibration adjustment for each load change, means **156** may be provided between the converter **154** and the regulator. The calibration adjust means may take the form of a number of resistors arranged to be selectively connected. The switching of the resistors may be effected by the use of a switch **44'** similar to the switch **44** for selecting the load.

FIG. **7** illustrates an embodiment wherein means **158** is provided to sense the field current and to derive a DC signal proportional thereto. The DC signal is supplied as an input to the regulator **34** so that the regulation as in the case of the embodiment of FIG. **6** is effected by signals responsive to both output amplitude and frequency. Again, as in the case of the embodiment of FIG. **6**, a calibration adjustment **160** may be provided ganged as indicated by the dotted line **44''** with the load selection switch **44**.

Field current is related to the rotation rate of the generator because the output voltage is proportional to $d\phi/dt$. A high field current will produce more total magnetic flux ϕ. Rotation of the rotor causes field ϕ to vary at the rate $d\phi/dt$, due to machine construction. Field current required to maintain constant voltage output is inversely related to rotation rate (as is well known from the basic principles of this type of machine, the alternator or AC generator) of the rotor. By sensing the field current and using this signal to increase the adjustment of regulator **34** to a higher value (at low RPM, where field current is highest) the load **30** can be used to compensate for variable losses. At higher RPM, the field current will be less, and the increased adjustment of the voltage regulator will be reduced.

While the invention has been described in connection with a number of different embodiments, it is intended to cover by the claims forming a part of this specification all variations which fall within the scope of these claims and the disclosure.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. In an exercising apparatus having a first rotatable element to be driven by an operator and a second rotatable element driven thereby, the improvement comprising:

an alternating current generator mounted on the exercising apparatus and having mechanical connections to the second driven element so as to be rotated thereby;

load means;

selective switching means connected to the output of said generator and to said load means;

a regulator for maintaining the output of said generator at a constant predetermined voltage; and

means connected to the output of said generator and responsive to the output frequency thereof for varying the load on said generator to compensate for variations in the output frequency to maintain the horsepower input of said generator at a constant value.

2. In the apparatus of claim 1 wherein said load means comprises a plurality of series connected resistors and said selective switch means comprises a multiposition switch connected to intermediate points in said series connected resistors.

3. The apparatus of claim 1 wherein said compensating means comprises a circuit producing an electrical signal proportional to the output frequency of said generator, an auxiliary load and switch means connected between said auxiliary load and the output of said generator controlled by said electrical signal.

4. The apparatus of claim 3 wherein said compensating means comprises means for producing a square wave having a frequency proportional to the output frequency of said generator, means for differentiating said square wave and means for integrating one-half of said square wave.

5. The apparatus of claim 4 wherein said switch means connected between said auxiliary load and the output of said generator comprises a transistor and wherein the integrated electrical signal is supplied to the base of said transistor to thereby control its state of conductivity

6. The apparatus of claim 3 wherein said means for producing said electrical signal comprises a circuit for producing a square wave output proportional to the output frequency of said generator and said switch means comprises a monostable multivibrator.

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